PINE FOREST RADIOCAESIUM ACTIVITY IN MEDITERRANEAN MOUNTAINS

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ABSTRACT

Radiocaesium activity was studied in 11 pine forests in Catalonia (NE Spain) with different combinations of species, lithology and altitude. Levels of ^{137}Cs in needles decreased from those which had sprouted before the Chernobyl accident, to younger ones. The activity detected in needles sprouting after the Chernobyl accident was attributed to retranslocation from older ones. Total ^{137}Cs activity in litter layers increased from L to H and was related to the degree of litter decomposition. It was assumed that a major ^{137}Cs fallout fraction in F and H was incorporated by mechanical soil mixing from faunal activity. Radiocaesium activity in the upper 15 cm of mineral soil came from weapon fallout deposition (from 2931 to 7359 $Bq.m^{-2}$). Soil ^{137}Cs correlated positively with organic soil carbon. The different distribution of Chernobyl activity with respect to weapon fallout activity suggests mobility for radiocaesium in the soil layers.

INTRODUCTION

The role of forest canopy in radionuclide retention has been shown in different studies (ref 1,2). Litter dynamics determines radiocaesium incorporation in the forest ecosystem.

The aim of the present work is to study the radiocaesium cycle in pine forests, paying special attention to forest floor layers.

MATERIALS AND METHODS

Different pine forest areas were sampled in the northern third of Catalonia (NE Spain).

11 plots were sampled, accounting for different types of pine species (Pinus halepensis, Pinus nigra, Pinus sylvestris, Pinus uncinata) and lithology. Composite samples were taken from needles, L, F and H horizons in the forest floor and the upper 15 cm of mineral soil. Needles of different age were considered separately. Mineral soil samples were sieved to 2 mm and analyzed for physicochemical characterization and radiocaesium activity. Needles and forest floor layers were ground and analyzed for C and N, and gamma activity.

Radioactivity was measured by gamma spectrometry using a Ge(Li) coaxial detector with an active volume of 58 cc, connected to a multichannel analyzer. Calibration was carried out with an Amersham cocktail of isotopes for different geometries and densities. The time of measurement was between 10000 and 70000 seconds for standards and between 80000 and 150000 seconds

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for samples. Radiocaesium activities were corrected for the time of sampling and also for the time of deposition, and expressed in $Bq.Kg^{-1}$ of dry weight or $Bq.m^{-2}$ taking bulk density of the soil samples into account.

RESULTS AND DISCUSSION

The deposition coming from Chernobyl was determined from ^{134}Cs activity, assuming a ^{137}Cs / ^{134}Cs ratio of 1.75 (ref 2,3) and corrected for the sampling date.

Differences in radiocaesium activites were not significant for the species and lithology studied.

^{137}Cs from Chernobyl was always the lower fraction of total radiocaesium activity.

The total activity from Chernobyl ranged from 36.4 to 2183 $Bq.m^{-2}$ and that from weapon fallout ranged between 3160 and 7480 $Bq.m^{-2}$.

Mineral soil was the ecosystem compartment with the highest amount of radiocaesium contamination. Tree canopies had no detectable radioactivity or radioactivity mostly coming from Chernobyl.

Radiocaesium concentrations in needles were studied for different needle ages. The older needles had sprouted before the Chernobyl deposition and received the contamination directly. The younger ones were separated in two groups: 1-year-old (sprouted May 1987) and 2-year-old (sprouted May 1986, after the Chernobyl deposition). The activity concentration decreased from older to younger needles. The lower activity detected in younger needles was attributed to retranslocation from older ones; there was no ^{137}Cs root uptake from the weapon fallout pool in the soil.

Some samples of three or more years old needles did not show any measurable radiocaesium activity, but the L layer in the same plots did show activity, indicating washout or surface needle aerosol weathering (ref 4) during the two years elapsed between Chernobyl deposition and the date of sampling.

Table 1. Distribution of ^{137}Cs in forest floor layers.

		$Bq.m^{-2}$		$Bq.Kg^{-1}$	
horizon	n	Chernobyl	Fallout	Chernobyl	Fallout
L	11	11.7 ± 7.2	11.7 ± 6.4	28.8 ± 17.1	27.8 ± 14.6
F	10	36.4 ± 17.5	169.1 ± 87.0	36.7 ± 16.4	149.9 ± 47.0
H	11	55.5 ± 36.9	595.9 ± 355.7	34.8 ± 21.2	219.2 ± 68.9
0-15 cm	11	420.3 ± 516.3	4504.0 ± 1107.0	3.3 ± 3.9	32.6 ± 8.9

The L horizon was composed of needles that received direct deposition from Chernobyl in the canopy. The relative proportion of activity attributable

to Chernobyl decreased from L to upper mineral soil, but the total ^{137}Cs activity increased from L to upper mineral soil and was related to the degree of litter decomposition (table 1).

The F layer was composed of plant remains coming from needles and litter layer (L) which received direct deposition from Chernobyl. The mixing faunal activity has incorporated mineral soil radiocaesium from weapon fallout in this layer. The higher concentrations of Chernobyl activity were found in L and F layers, as reported in others studies (ref 2,5,6).

The H horizon was made of unrecognizable organic debris in advanced decomposition stage mixed with mineral particles from the upper mineral soil by faunal activity; faunal mixing and leaching explained the radiocaesium activity from Chernobyl found in this layer.

The general trend of ^{137}Cs accumulation in the most decomposed organic horizons agreed with the negative correlation between radionuclide specific activity and the percentage of organic carbon ($r=-0.74$, $P<1\%$) and C/N ratio ($r=-0.79$, $P<1\%$) on the forest floor.

The upper 15 cm of mineral soil showed a positive correlation between the organic carbon content and ^{137}Cs activity ($r=0.54$, $P<10\%$) in agreement with other authors (ref 7). There was no correlation between pH, clay content or $CaCO_3$ and ^{137}Cs activity. In this soil layer the proportion of radiocaesium activity from Chernobyl ranged from 0% to 24% of the total.

CONCLUSIONS

The different distribution of Chernobyl activity with respect to weapon fallout activity suggests slow mobility for radiocaesium in the soil layers, due to leaching and mechanical mixing from faunal activity.

The role of faunal activity in the migration of radiocaesium is an outstanding feature of Mediterranean conditions.

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